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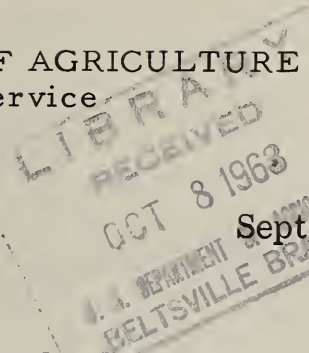
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PIPER PA-25 "PAWNEE" DISTRIBUTION PATTERNS

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After World War II until recent years nearly all aircraft used in aerial application of agricultural chemicals were war surplus ranging from trainers to heavy bombers, none very suited to their new use. Their performance and flying characteristics left much to be desired, and their structural design often made it difficult to properly install equipment for aerial applications.

One of the first aircraft specifically designed for agricultural use was the Ag-1, developed at the Texas A. & M. Aircraft Research Center in 1949-50 under the supervision of Fred E. Weick. This development was sponsored by the U.S. Civil Aeronautics Administration, ² The National Flying Farmers Association, the U.S. Department of Agriculture, the Texas A & M College System, and several airplane manufacturers. After completion, this airplane was tested and demonstrated by the CAA in several geographical areas of the United States.

Transland Aircraft, Torrence, Calif., a division of Hi-Shear Rivet Tool Company, ³ developed the Ag-2. This was a second and larger version of the Ag-1. The Ag-2 was first type-certificated in 1958.

A third and smaller version of the Ag-1, known as the Ag-3, was developed and constructed under the supervision of Fred E. Weick at the Texas A. & M. Aircraft Research Center with the aid of Piper Aircraft Corporation. The Ag-3 contained many standard Piper parts. Research and development of the airplane was then taken over by Piper Aircraft; with modification it became the prototype of the PA-25. The company described the aircraft as "being constructed with as many standard Piper PA-18 and PA-22 parts as possible." ⁴ Following type certification in 1959, the PA-25 was known as "Pawnee" (fig. 1).

A series of deposit pattern tests was made with the PA-25 "Pawnee" by the Agricultural Research Service field station, Forest Grove, Oreg., to determine the effective swath width ⁵ and

¹ Aircraft Pilot, Agricultural Engineer, Agricultural Engineering Research Division, ARS, and Entomologists, Entomology Research Division, ARS, respectively. Located at Forest Grove, Oreg.

² The CAA was superseded in 1959 by the U.S. Federal Aviation Agency.

³ Mention in this publication of commercial companies and products does not imply endorsement of any particular commercial concern or product.

⁴ American Society of Agricultural Engineers, Sub-Committee on Agricultural Aviation, Summary of Second Survey on Research in Engineering Areas of Agricultural Aviation. In Agricultural Aviation Research Conference Report (1958) 3: 68-72. 1959. (Published by Agricultural Research Service, U.S. Department of Agriculture.)

⁵ "Effective swath width" means the maximum width of swath over which a deposit equal to the mean rate is obtained, taking into account overlaps of adjacent swaths.



Figure 1.--Piper PA-25 "Pawnee" making application of dust.

distribution of deposit rate across the treated swath (uniformity of coverage) for both spray and granular formulations. Placement of nozzles and the adjustment of distributor louver doors were investigated to determine their relationship to pattern characteristics. These studies were conducted in cooperation with the Piper Northwest distributor, Hillsboro Aviation, Hillsboro, Oreg.

Deposit pattern studies involving a number of different aircraft have been conducted by the Forest Grove station. These investigations showed that several factors acting independently and collectively contribute to the overall swath pattern and that the predominantly contributing factors are size of the engine and propeller, wing loading, wingspan, speed, and type of aircraft.

DESCRIPTION OF EQUIPMENT

The Piper PA-25 "Pawnee" is a low-wing monoplane manufactured by the Piper Aircraft Corporation at Lock Haven, Pa. The plane used in these tests was powered by a 150 hp. engine and had a 2-blade, fixed-pitch propeller. The designated useful load was 1,100 pounds.

Spray dispersal equipment supplied by Piper Aircraft for installation by ARS included a noncorrosive hopper tank (20 cu. ft. capacity) with a quick-acting dump valve; 4664-D-12-56 nozzles for low-density applications (25 nozzles) and high-density applications (46 nozzles); and an externally mounted 1-inch Simplex pump driven by a wooden-bladed windmill fan. A 1-inch inside-diameter spray boom, mounted aft and slightly above the trailing edge of the wing, extended 15 feet outboard right and left of center.

The company also furnished for installation a dry-materials distributor of their standard type, a fan-shaped split-type spreader with vanes inside providing three air ducts each side of center. Each of the two center vanes had an adjustable louver door, the doors being opposite each other in the "V" section of the split spreader. These doors could be set at various positions to assist in producing a desired deposit pattern.

SPRAY DISTRIBUTION PATTERNS

The spray tests were conducted at flight elevations ranging from 3 to 8 feet and at indicated airspeeds approximately 87 m.p.h.

The spray formulation for these tests consisted of water to which Dupont Pontacyl Carmine 2B dye (1 pound to 50 gallons of water) had been added as a tracer. Samples of the deposited spray were collected on 3- x 6-inch stainless steel plates. These plates were spaced at 1-foot intervals along multiple 100-foot sampling lines, which transected the line of flight at right angles with midpoints located on the line of flight.

The analytical procedure consisted of recovering the dye from each sampling plate with 50 ml. of water and determining the color intensity of the resultant solution by means of a logarithmically scaled photoelectric colorimeter. On the basis of a reading of the color value for the recovered sample and for a known dilution of the original spray mix, the spray deposit was computed by formula to gallons per acre for each of the sample areas.

The initial pattern test for the series employed the factory-recommended asymmetrical arrangement of 46 nozzles, followed by a subsequent series using the recommended asymmetrical, low-density arrangement of 25 nozzles (fig. 2). The results of these two asymmetrical tests

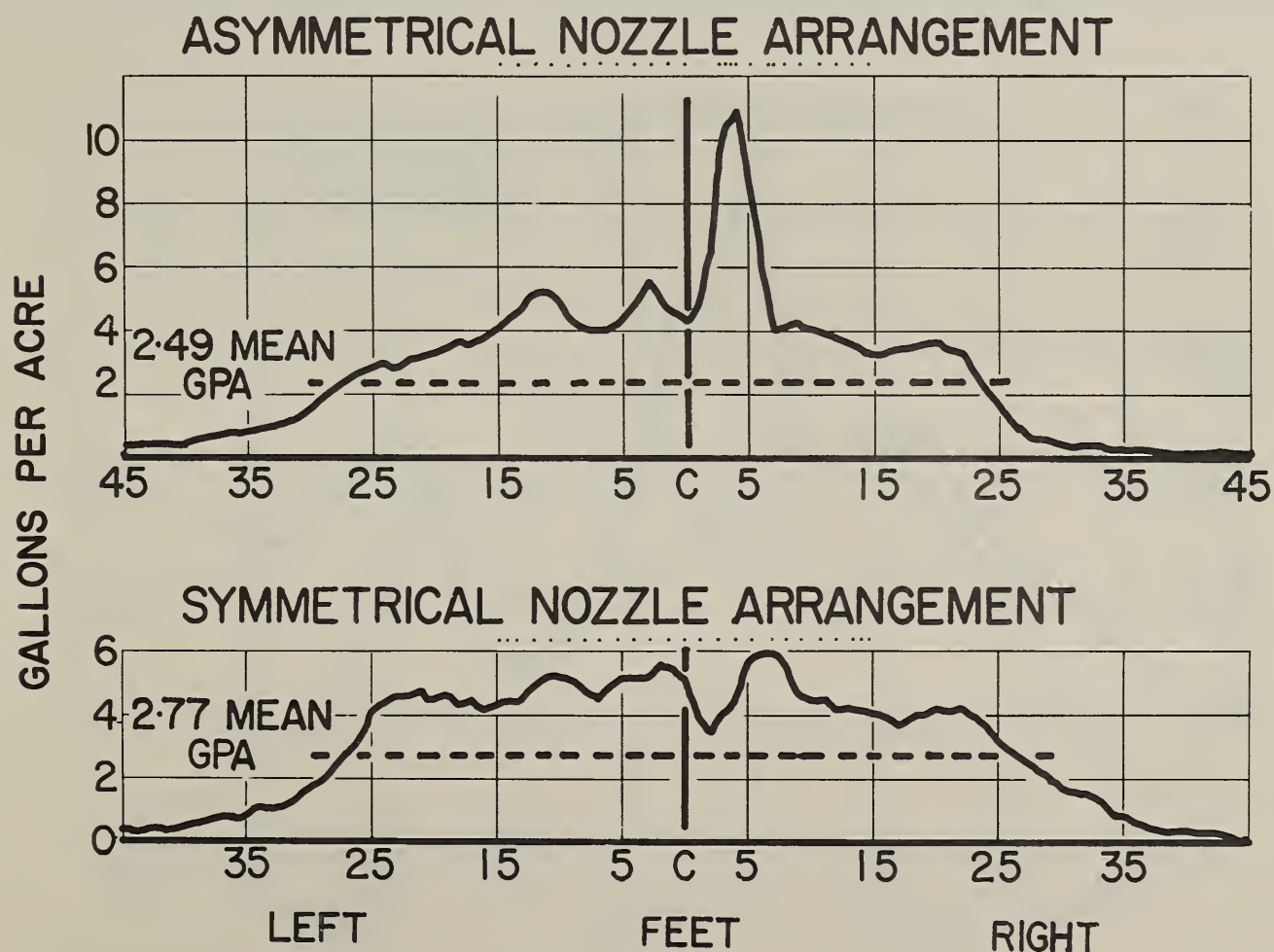


Figure 2.--Spray distribution curves for asymmetrical and symmetrical arrangements of 25 nozzles on a Piper PA-25 "Pawnee" low-wing monoplane. Series mean curves for flight elevations of 3 to 8 feet.

had similar characteristics, notably a very high deposit zone right of center directly below the concentration of nozzles located 40 to 48 inches outboard.

The pattern studies discussed in USDA Technical Bulletin No. 1110⁶ were reviewed. These studies, pertaining to a Stearman biplane equipped with a symmetrical nozzle arrangement, characteristically showed a low deposit zone right of center and a high one left of center. The data showed that with this biplane an asymmetrical nozzle arrangement improved the uniformity of the spray deposit rates across the treated swath (fig. 3). The concentration of nozzles 3 feet to the right of center by the transfer of those within 3 feet left of center reduced the high coverage left of center by compensating for the crossover of spray from right to left that results from the propeller's directional rotation.⁷

Pattern studies were also conducted in 1960, with a Rawdon T-1 low-wing monoplane, to determine the relative effect of symmetrical vs. asymmetrical nozzle arrangements on the overall patterns produced. In these tests, 48 nozzles were employed for the asymmetrical and 49 for the symmetrical arrangement, the additional nozzle being located in the center of the

⁶Chamberlin, J. C., Getzendaner, C. W., Hessig, H. H., and Young, V. D. Studies of Airplane Spray-Deposit Patterns at Low Flight Levels. U.S. Dept. Agr. Tech. Bul. 1110, 45 pp.

⁷This crossover is not as pronounced with smaller aircraft having lower horsepower engines and smaller propellers, such as the 150 hp. Rawdon and Pawnee and the 90-hp. Piper Cub. Because of this, the results of tests with the Stearman biplane cannot be projected to or used in the analysis of patterns of the 150-hp. Rawdon or Pawnee airplane.

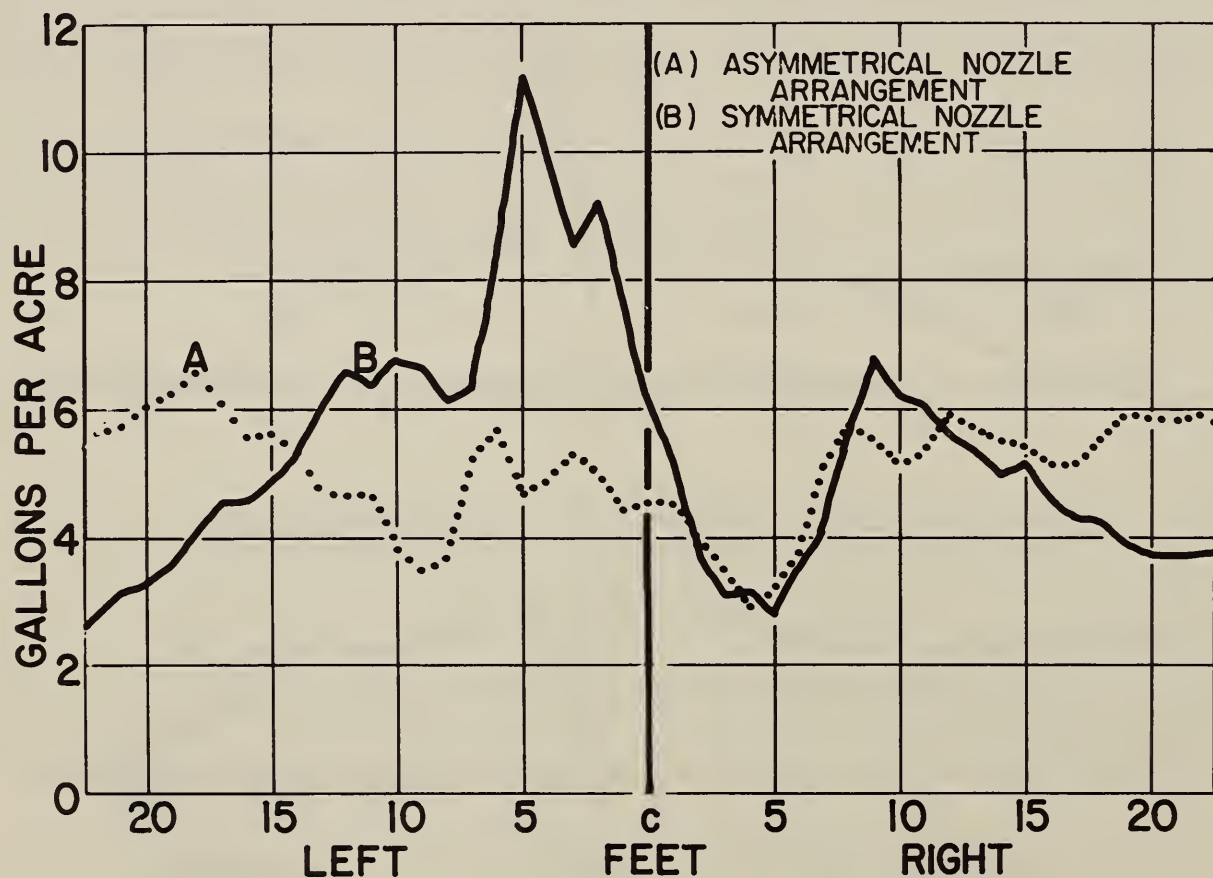


Figure 3.--Spray distribution curves for asymmetrical and symmetrical nozzle arrangements on a high-lift Stearman biplane. Series mean curves for flight elevations of 3 to 8 feet.

boom. The data gathered indicated that no appreciable improvement could be expected in the uniformity of deposit rate with an asymmetrical as compared with a symmetrical nozzle arrangement for low-wing monoplanes equipped with low-horsepower engines (fig. 4).

On the basis of the Rawdon monoplane data, it appeared that the spray deposit pattern being laid down by the PA-25 "Pawnee" monoplane, with the factory-recommended nozzle arrangements, could perhaps be improved upon by switching to a symmetrical arrangement. One nozzle was installed in the center position, and the other 24 in a symmetrical arrangement right and left of center at the following distances (in inches): 15½, 32, 48, 64, 80, 96, 112, 128, 144, 160, 168, and 176. Pattern tests were made and the data were compiled and analyzed. The plotted mean curve of deposit (fig. 2) in fact did not show the extremely high application zone right of center evident in the tests with the asymmetrical nozzle arrangement. The curve had a more or less trapezoidal shape, the differences in application rate being reasonably uniform along the swath. An effective swath width of approximately 62 feet was obtained compared with 57 feet for the asymmetrical arrangement, with no loss in mean deposit level.

GRANULAR DISTRIBUTION PATTERNS

Deposit pattern tests were made with the PA-25 "Pawnee" to determine deposit rates, uniformity of deposit, and swath width when applying a 30/60-mesh granular attapulgite clay.

NOZZLE ARRANGEMENTS

(A) ASYMMETRICAL

(B) SYMMETRICAL

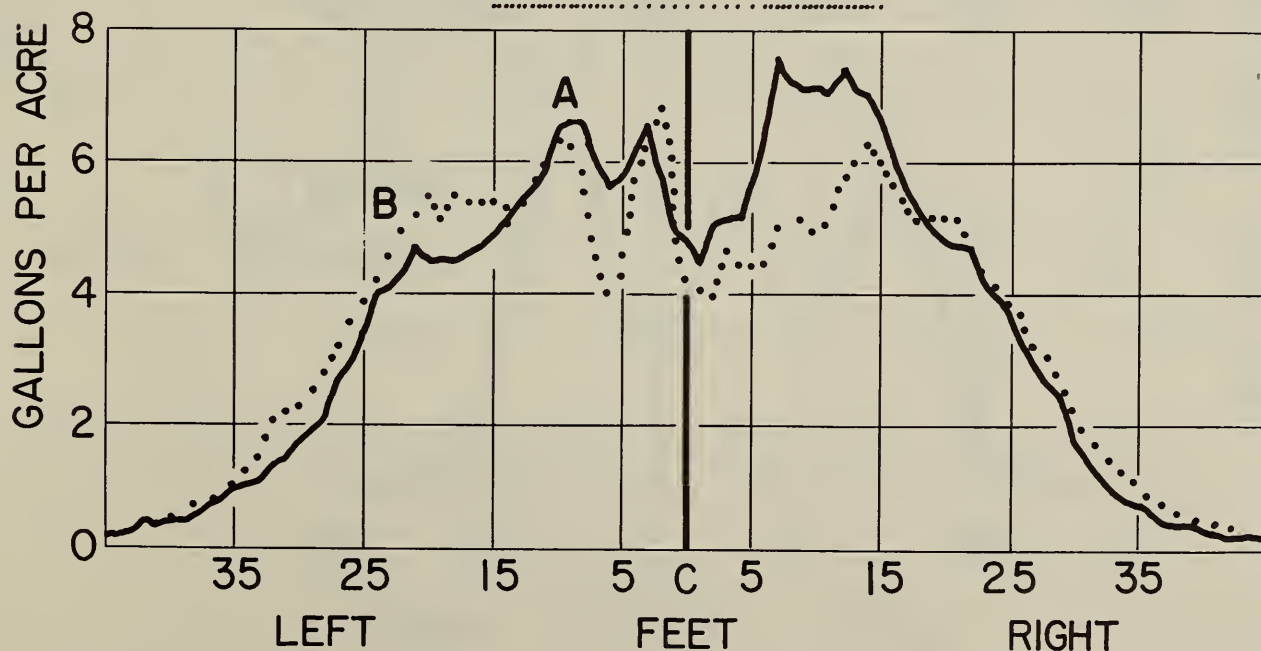


Figure 4.--Spray distribution curves for asymmetrical and symmetrical nozzle arrangements on a Rawdon T-1 low-wing monoplane. Series mean curves for flight elevations of 3 to 8 feet.

Four flight elevations were employed in the granular tests; namely, 5, 8, 12, and 25 feet. The application speed was 80 m.p.h.

Deposit samples were collected in shallow milk pans measuring 12 inches in diameter spaced at 2-foot intervals along 100-foot sampling lines transecting the line of flight at right angles. The rate of deposit expressed as pounds per acre was computed on the basis of size of sampling area and weight of sample.

An application was made at a flight elevation of 5 feet with the adjustable louver doors in the center vanes closed. The plotted mean curve of deposit shows a pronounced "peak" (high-concentration zone) each side of the center flight line and a "trough" (low concentration) approximately at the line of flight (fig. 5).

An additional test was made at a flight elevation of 8 feet after the louvers were adjusted, i.e., the louver doors in the center section of the distributor outlet were opened. The deposit

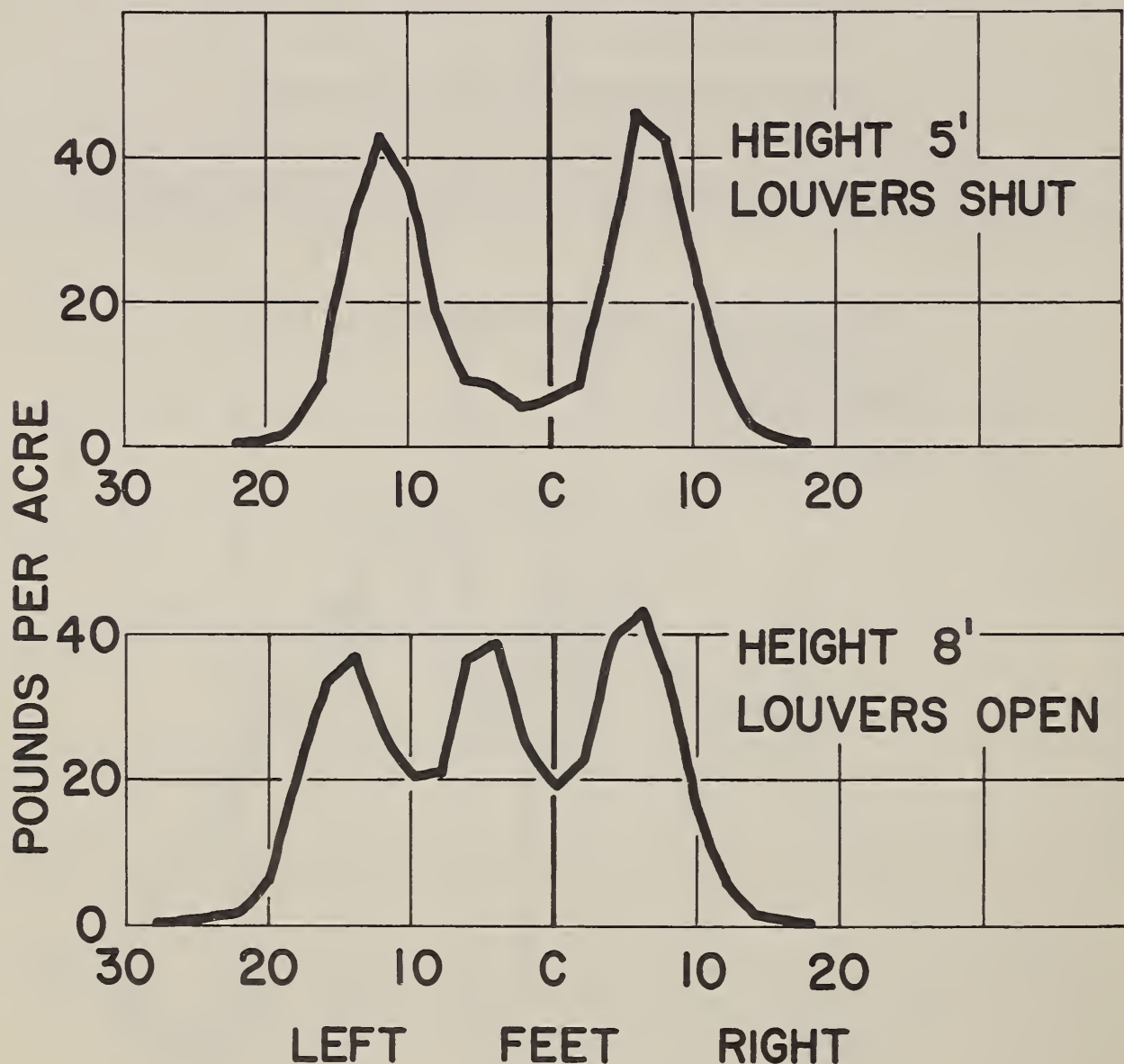


Figure 5.--Granular distribution curves for a distributor, with louvers shut and open, on a Piper PA-25 "Pawnee" low-wing monoplane. Series mean curves for flight elevations of 5 and 8 feet.

curve for this test shows the center zone of the swath filled in (fig. 5). That is, the low concentration in this zone is corrected. A mean deposit rate of 18 lb./acre was obtained over an effective swath of 32 feet.

Additional tests were conducted at 12- and 25-foot flight elevations in which the louver doors were opened to their maximum, and closed. The zone of low concentration is still pronounced for the 12-foot application height with the louver gates closed (fig. 6). The pattern for the 25-foot flight elevation shows that the center section of the swath pattern was filled in when the louver doors were open. At this elevation, the mean deposit rate was 16.8 lb./acre, the effective swath at this rate level being 39 feet.

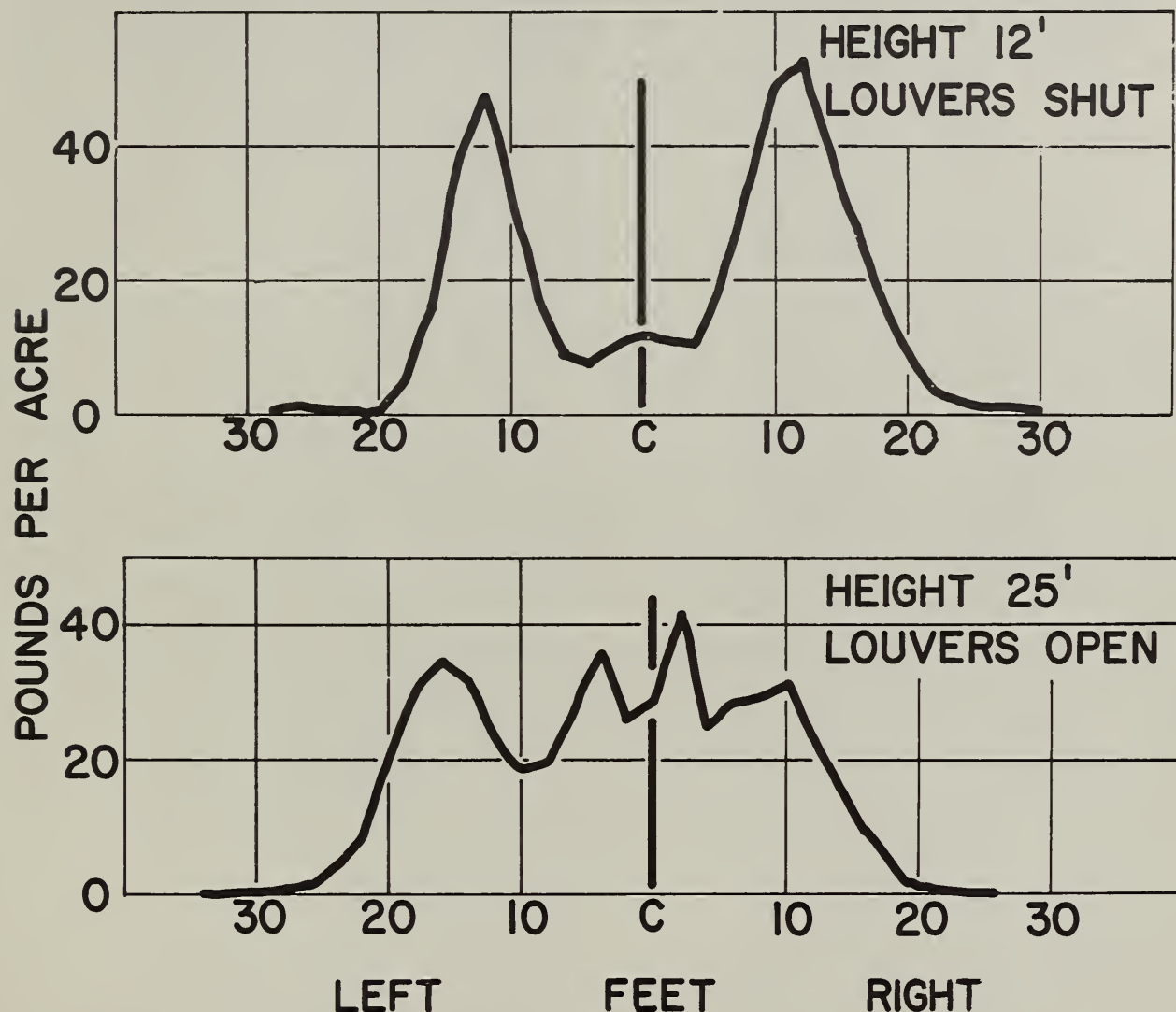


Figure 6.--Granular distribution curves for a distributor, with louvers shut and open, on a Piper PA-25 "Pawnee" low-wing monoplane. Series mean curves for flight elevations of 12 and 25 feet.

SUMMARY

Distribution studies were conducted with a Piper PA-25 "Pawnee" airplane, equipped with spray and dry-material dispensing equipment furnished by the company. The nozzle arrangements tested consisted of the factory-recommended asymmetrical nozzle arrangement, followed by a

symmetrical nozzle arrangement for comparison. Pattern curves were plotted for both arrangements.

Dry material application studies were conducted in which a 30/60-mesh attapulgate granular clay was used. The investigations were made to determine effect of louver-door position on uniformity of pattern produced.

A recapitulation of findings from the preceding comparative studies leads to the following summary of results of tests for the Piper PA-25 "Pawnee" airplane:

(1) These data corroborate the conclusions of previous tests with a Rawdon monoplane, viz., that an asymmetrical nozzle arrangement does not appear to improve the uniformity of deposit rate across the treated swath for aircraft equipped with low horsepower engines.

(2) The effective swath width is increased approximately 5 feet when the symmetrical nozzle arrangement is employed.

(3) The deposit pattern curve for the symmetrical nozzle arrangement test is of trapezoidal shape and reasonably regular in rate variation.

(4) The data for the series of granular tests indicate that a reasonably uniform deposit pattern over an effective 32-foot swath may be obtained with the PA-25 "Pawnee" and the factory-recommended distributor when the material is applied from a 5- to 8-foot flight elevation.

(5) For the heights of flight used in these tests, the most uniform pattern of coverage of granular materials across the treated swath was obtained with the middle louver doors of the distributor outlet open.